

Hadron structure with light dynamical quarks:
moments of parton distributions

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Lattice 2005

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Nucleon structure calculations are described using a hybrid combination of improved staggered sea quarks and domain wall valence quarks at a range of pion masses extending down to 350 MeV. Results are presented for moments of unpolarized, helicity, and transversity distributions. Recently calculated one loop perturbative renormalization factors are included.

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for LHPC, in particular

R. Edwards

G. Fleming

Ph. Hägler

J. Negele

K. Orginos

A. Pochinsky

D. Richards

W. Schroers

<http://talks.drubryantrenner.org/lattice05.pdf>

Nucleon Structure with Light Dynamical Quarks

- moments of parton distributions - DBR
- electromagnetic form factors - George Fleming
- generalized parton distributions - Wolfram Schroers

Moments of Parton Distributions

- for example, unpolarized twist two operators

$$O_q^{\mu_1 \dots \mu_n} = \bar{q} i D^{(\mu_1} \dots i D^{\mu_{n-1}} \gamma^{\mu_n)} q$$

- moments of parton distributions, forward matrix elements

$$\langle P, S | O_q^{\mu_1 \dots \mu_n} | P, S \rangle = 2 \langle x^{n-1} \rangle_q P_{\mu_1} \dots P_{\mu_n}$$

- unpolarized, helicity and transversity

$$\begin{aligned} \langle x^n \rangle_q &= \int_{-1}^1 dx x^n q(x) \\ \langle x^n \rangle_{\Delta q} &= \int_{-1}^1 dx x^n \Delta q(x) \\ \langle x^n \rangle_{\delta q} &= \int_{-1}^1 dx x^n \delta q(x) \end{aligned}$$

- please see, for example, [hep-lat/0201021](https://arxiv.org/abs/hep-lat/0201021) for more details

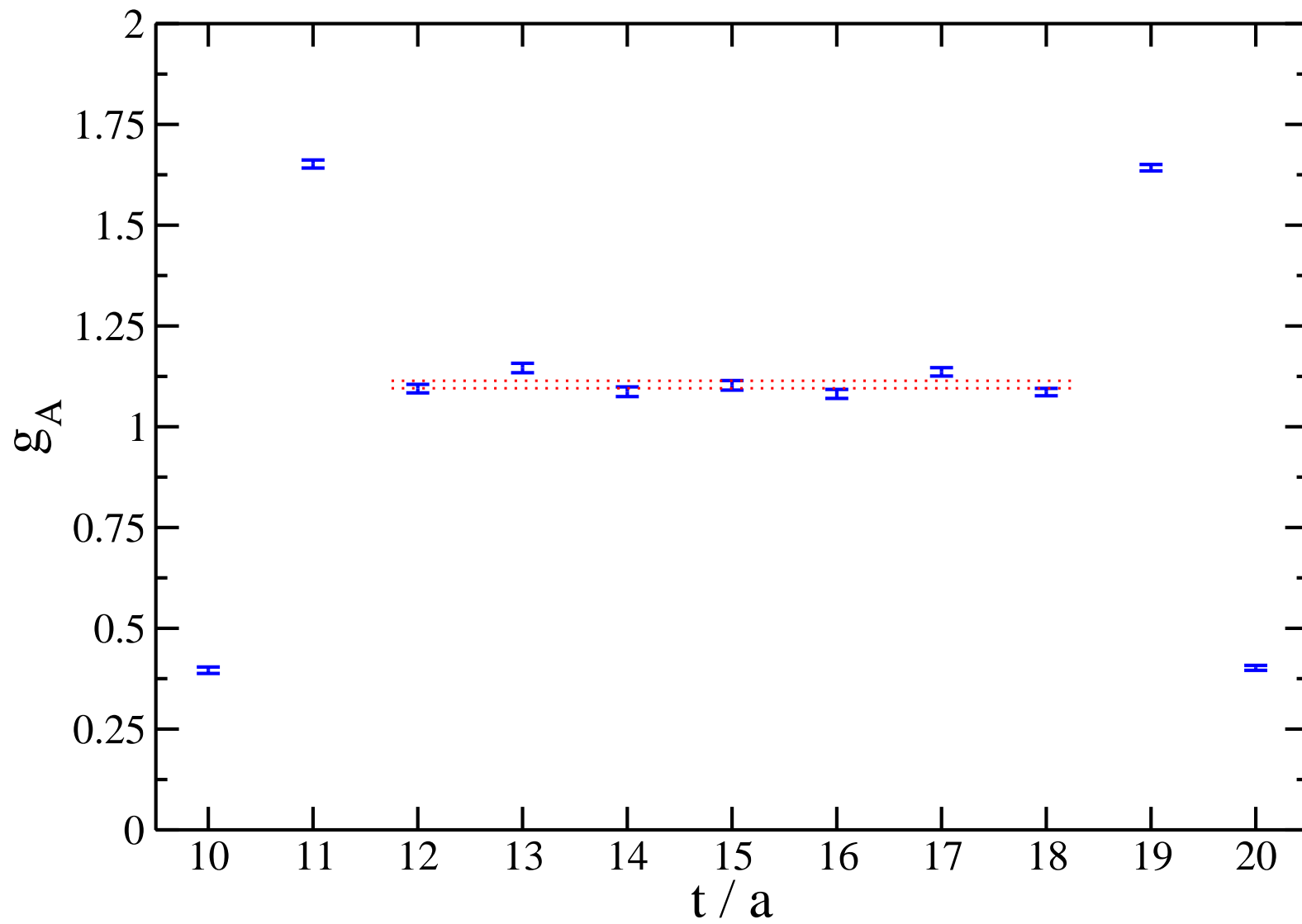
Hybrid Lattice Action

- asqtad staggered sea quarks (MILC) with $a = 0.126$ fm
- domain wall valence quarks with HYP smearing ($L_5 = 16$)

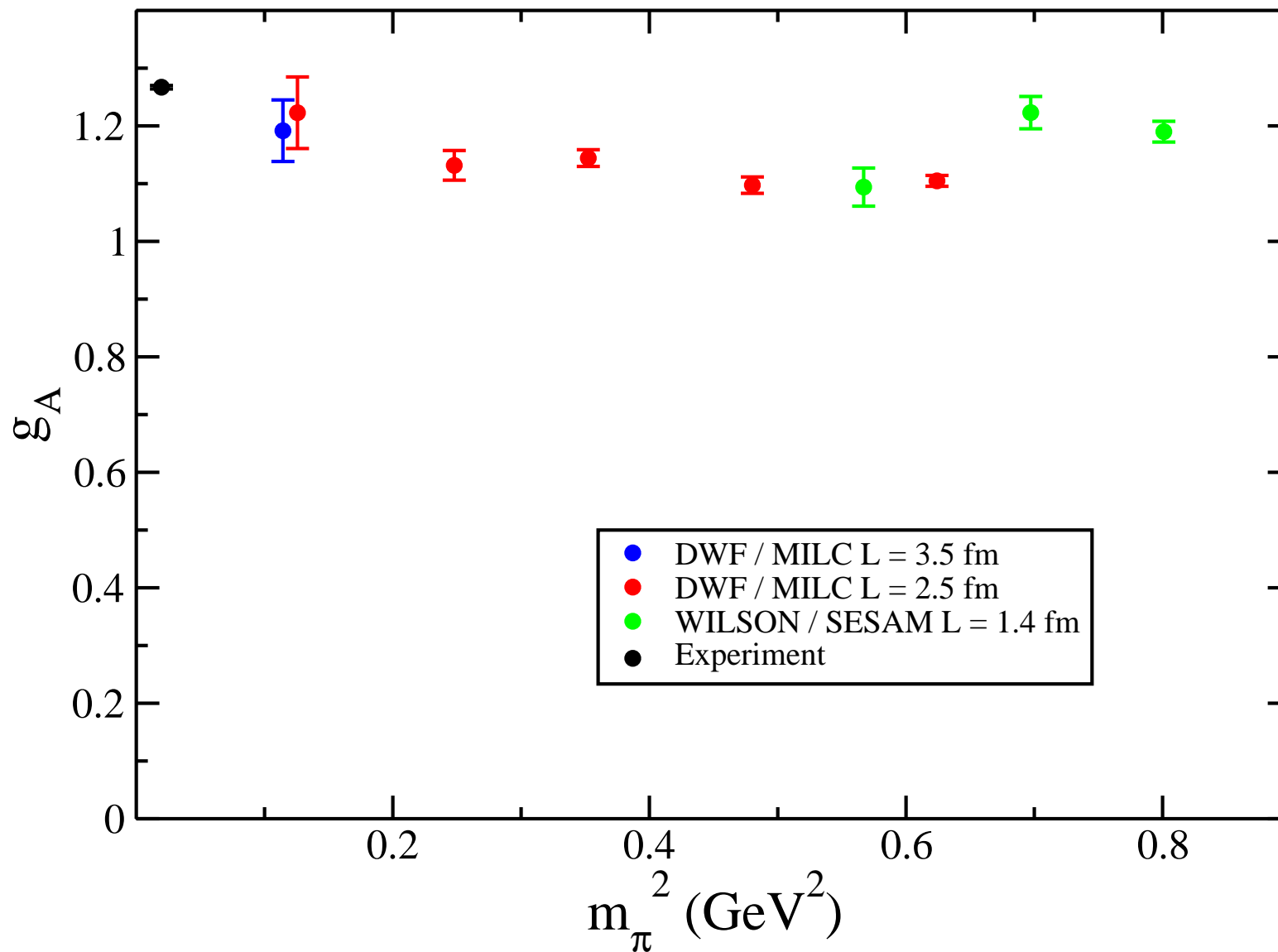
$am_{u/d}^{\text{asqtad}}$	L/a	L	$am_{u/d}^{\text{DWF}}$	m_{π}^{DWF}	#
		fm		MeV	
0.05	20	2.52	0.0810	775	425
0.04	"	"	0.0644	696	350
0.03	"	"	0.0478	605	564
0.02	"	"	0.0313	498	486
0.01	"	"	0.0138	359	656
0.01	28	3.53	0.0138	359	270

- one loop perturbative renormalization at $\mu = 2$ GeV by Bojan Bistrovic
- please see [hep-lat/0409130](https://arxiv.org/abs/hep-lat/0409130) for more details

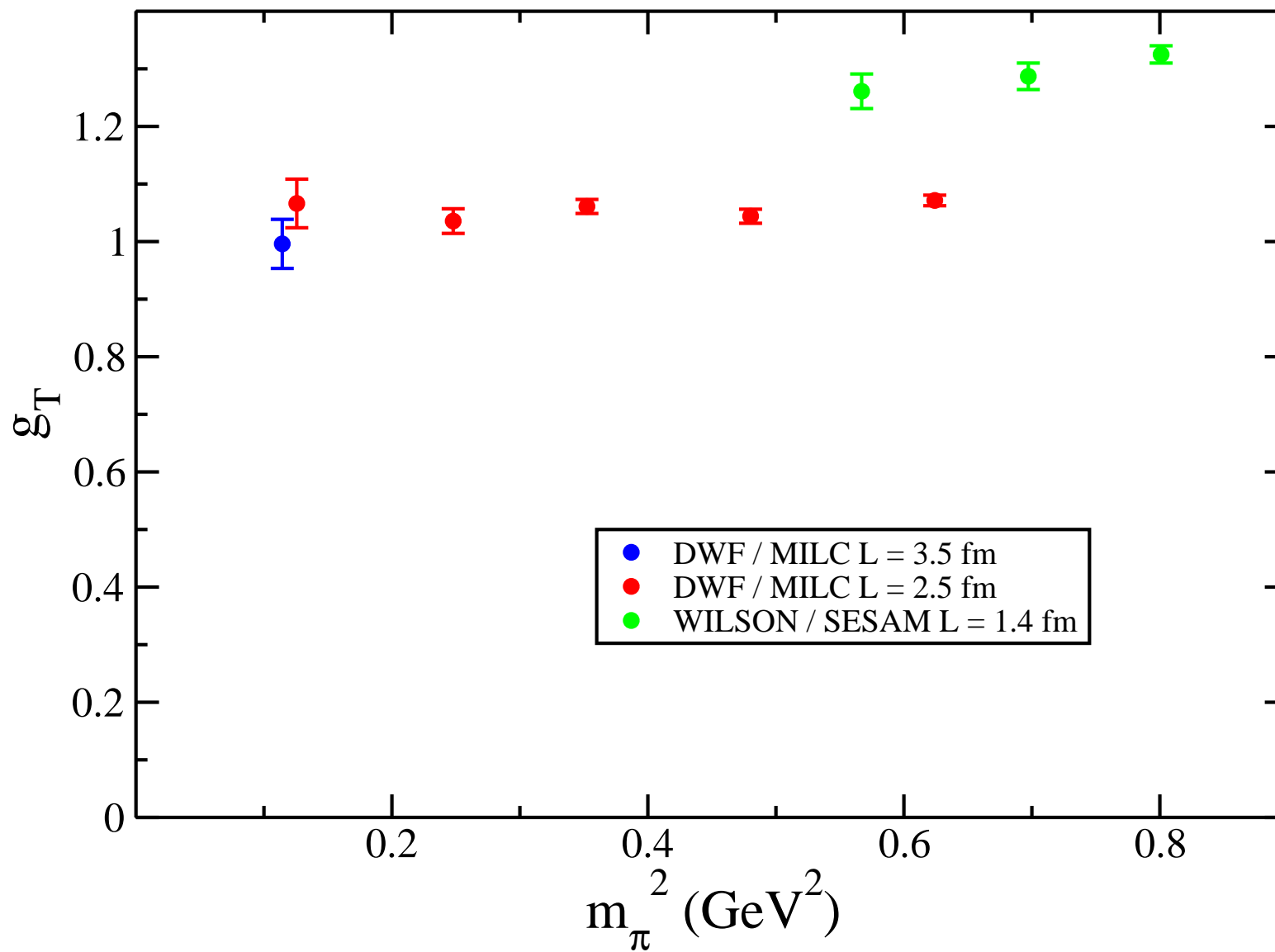
Example Plateau: $g_A = \langle 1 \rangle_{\Delta u - \Delta d}$



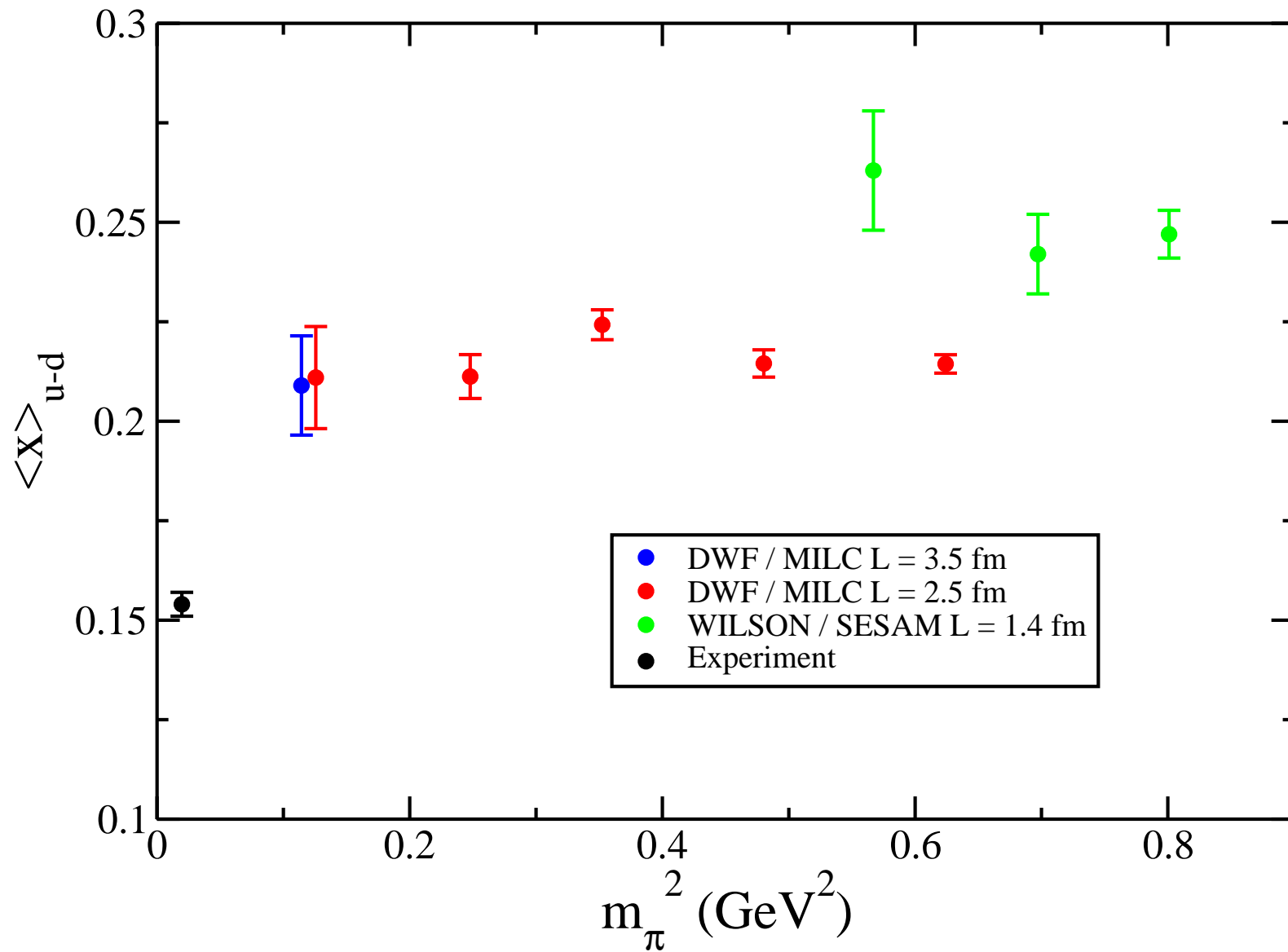
Axial Charge: $g_A = \langle 1 \rangle_{\Delta u - \Delta d}$



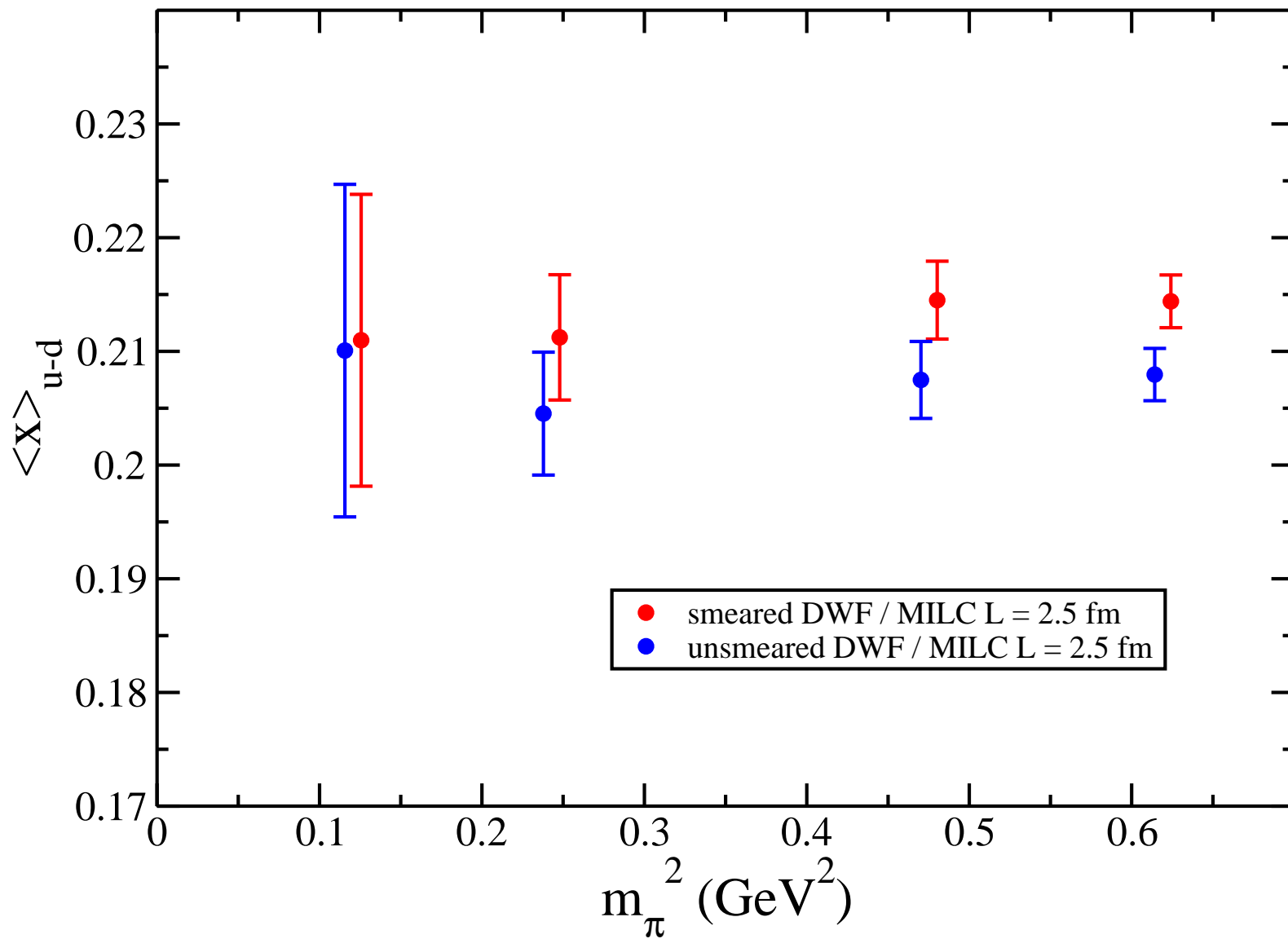
Tensor Charge: $g_T = \langle 1 \rangle_{\delta u - \delta d}$



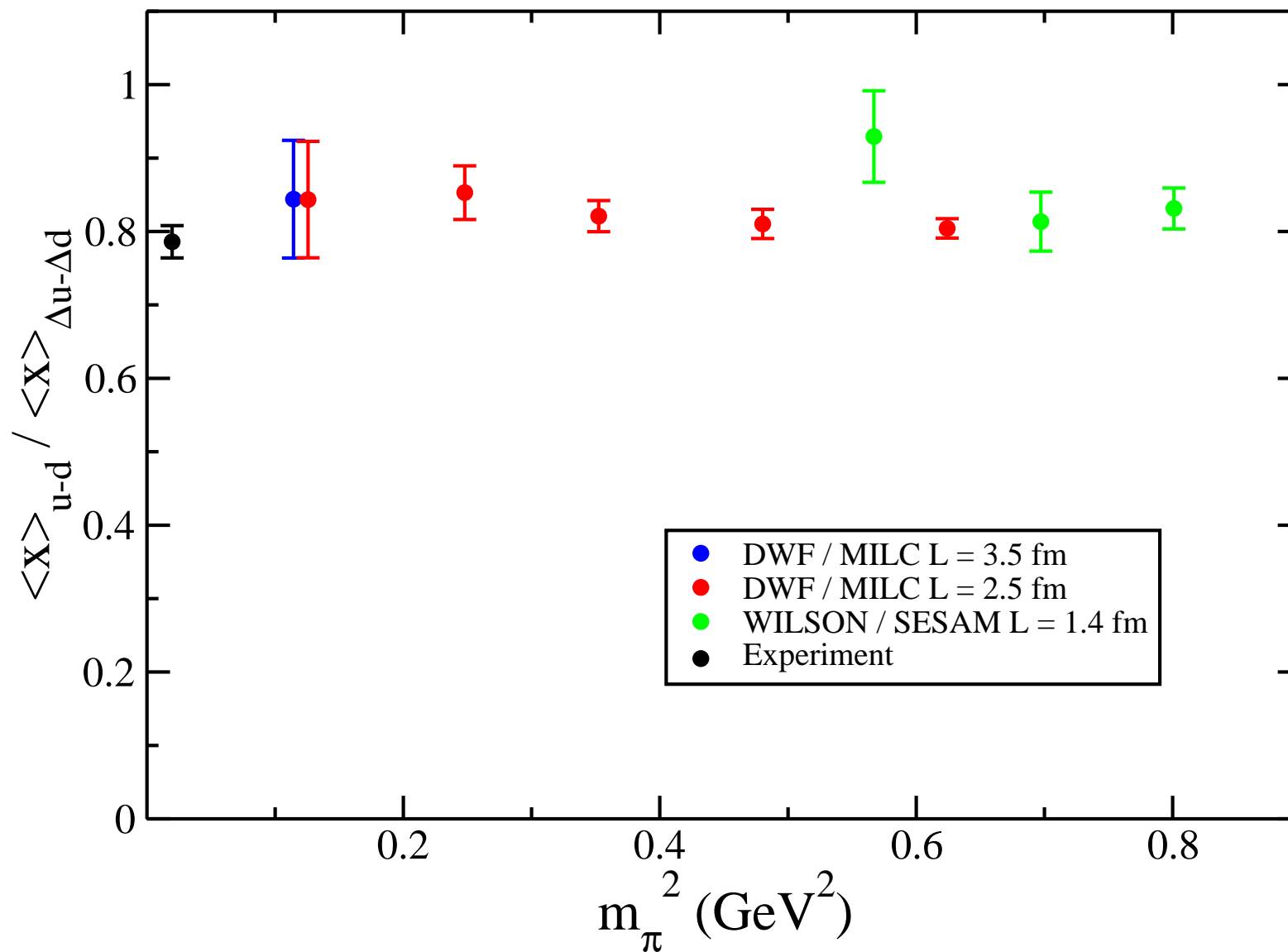
Momentum Fraction: $\langle x \rangle_{u-d}$



Momentum Fraction: Smearred and Unsmearred $\langle x \rangle_{u-d}$



Polarized Momentum Fraction: $\langle x \rangle_{\Delta u - \Delta d}$



Conclusions

- light quark calculations using DWF on staggered lattices with m_π down to 350 MeV and $L = 2.5$ and 3.5 fm
- puzzles in matching g_T and $\langle x \rangle$ between Wilson and DWF/staggered calculations
- however we find a reduced, by roughly 1/2, discrepancy between $\langle x \rangle_{u-d}$ and the experimental result
- $\langle x \rangle_{u-d} / \langle x \rangle_{\Delta u - \Delta d}$ is quite flat but nonetheless agrees with experiment at $m_\pi = 350$ MeV
- g_A shows just a bit of curvature and agrees with experiment at $m_\pi = 350$ MeV